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THESIS

COMPUTER ASSISTED INSTRUCTION:
TWO DECADES IN PERSPECTIVE

by

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and

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September 1987

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This thesis examines the changes that have occurred in Computer Assisted Instruction (CAI) over the past 20 years. Numerous literature sources were reviewed and the information extracted was utilized to describe the history of CAI; provide a brief description of other types of computer-based education that are often grouped under the heading of CAI; examine the changes in hardware and software costs; describe the interaction of educators and software developers; reflect on the future of CAI; examine the development of computer-based instruction for Navy technical training, and make some comparisons between the public sector's use of computer-based instruction and the Navy's. Conclusions center on the benefits of CAI with regard to learning improvement; inadequate teacher training; failure to plan for implementation of hardware and software, and the less than optimal, but improving, interaction between educators and software developers.

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Computer Assisted Instruction: Two Decades in Perspective

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ABSTRACT

This thesis examines the changes that have occurred in Computer Assisted Instruction (CAI) over the past 20 years. Numerous literature sources were reviewed and the information extracted was utilized to describe the history of CAI; provide a brief description of other types of computer-based education that are often grouped under the heading of CAI; examine the changes in hardware and software costs; describe the interaction of educators and software developers; reflect on the future of CAI; examine the development of computer-based instruction for Navy technical training, and make some comparisons between the public sector's use of computer-based instruction and the Navy's. Conclusions center on the benefits of CAI with regard to learning improvement; inadequate teacher training; failure to plan for implementation of hardware and software, and the less than optimal, but improving, interaction between educators and software developers.

COMPUTER ASSISTED INSTRUCTION: TWO DECADES IN PERSPECTIVE

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I. INTRODUCTION

Over the past 20 years much has been written with regard to the computer as an instructional device. Information in the literature has run the range from determining where in the context of the classroom the computer would fit, how the computer would present information to the student, the hardware and software that were required to achieve this, the cost for such systems and methods to reduce the cost of computerized instruction. New phrases were added to the language of education and the computer sciences. Such terms as teaching machine and automated instruction gave way to phrases such as computer-based instruction and computer assisted instruction.

As technology progressed and the use of computers in the classroom gained momentum, literature sources for such information likewise grew in number. Topics began to focus on various methodologies of instruction by way of the computer. Terms such as drill and practice, tutorial, PLATO and individualized instruction became common words in education circles. Articles were written to describe new hardware systems, studies were conducted with regard to the benefits achieved from computer assisted instruction over conventional education and predictions were made as to the impact of computers on the future of education.

Not everything written however, was positive. Some argued that many teachers would be replaced by computers and others voiced their opinion as to the inadequacy of educational software and the lack of planning on the part of school boards with regard to introducing computers into the schools. Others called for more research with regard to how learning occurs in an individual with regard to computer-based education.

The purpose of this thesis therefore, is to examine the available literature sources and, through them, describe the changes that have occurred in Computer Assisted Instruction (CAI) over the past 20 years. The method chosen to locate the various literature sources was to use Lockheed's DIALOG Online Information Service to conduct a computer search of two library data bases. The data bases searched were Comprehensive Dissertation Abstracts and Educational Resource Information Center (ERIC), which is maintained by the U.S. Department of Education's Office of Educational Research and Improvement.

The two searches resulted in over 1000 sources dealing with computer assisted instruction. Abstracts were obtained regarding these sources and by process of elimination, the source list was reduced to approximately 100 titles. The full documents were then obtained through various sources. In addition to the data base searches, material was obtained from off-the-shelf at various public and university libraries.

The collected information was then reviewed, categorized and used as the basis for the various chapters of the thesis. Chapter I consists of an introduction. Chapter II contains the history of CAI. Chapter III describes various types of computer-based instructional/management systems as well as descriptions of specific styles of computer instruction. Chapter IV examines the changing cost of hardware and software. Chapter V reviews the adequacy of software and the interaction between educators and software developers. Chapter VI focuses attention on the future of CAI. Chapter VII describes the use of computers in Navy training and provides comparisons with their use in the public sector. Chapter VIII presents the summary, conclusions and recommendations.

Conclusions reached were that the use of CAI improves educational achievement; the cost of hardware is decreasing

while the cost of software continues to increase; interaction between educators and software developers has been less than optimal but is improving; more teacher training is required; schools and school districts have not used a well designed CAI hardware and software implementation plan, and that an organized and well funded approach to developing CAI systems, as demonstrated by the Navy CAI and Computer Managed Instruction (CMI) projects and the University of Illinois PLATO system, has a better chance of success.

Recommendations include continuing this research with regard to the use of CAI in the U.S. Navy. Specific issues to be addressed would include determining the current status of CAI in the Navy with regard to the Navy's goals for its use; reviewing the Navy CAI program with regard to areas being researched in order to further improve the instructional system, and determining what the Navy sees as its use of CAI in the future with regard to the manning requirements for a 600-ship Navy in an environment of changing demographics with regard to draft eligible males.

II. THE HISTORY OF CAI

History books tell us of several revolutions, some of which include the introduction of the written word and the invention of printing. From these came, during the nineteenth century, the introduction of mass education, which was based on the storage and dissemination of information. But this was not enough, for the effectiveness of the schools was not improving as time passed. Hence, the technological revolution came to be; the one we find ourselves currently in, with its center, or focal point being the computer. Since the beginning of this revolution, the methods in which information is stored and processed have been changed dramatically.

An Ohio State University professor, Sidney Pressey, enthusiastically supported this revolution. He felt as if it was the industrial revolution in education. His support though, was more than verbal support, for in 1926, he devised a machine called the "Pressey Testing Machine", one which tests as well as teaches. (B.F. Skinner, 1986, p. 103) In order to use this machine,

> A student studied the subject in the usual way and then turned to the machine. It [the machine] directed the student to a first item on a multiple-choice test, and the student made a choice by pressing a numbered key. If the choice was right, the machine moved on to the next item; if the choice was wrong, the student pressed another key. When the student went through the test a second time, the machine stopped only on those items on which the student's first choice had been wrong. (B.F. Skinner, 1986, pp. 103-104)

In the late 1950s, programmed instruction (PI) was considered to be the wave of the future. PI was an

> ...instructional method in which the student is lead through a series of questions, responses, and confirmation of his responses until little by little he has progressed from small bits of relatively simple knowledge to more complex principles. (U.S. Civil Service Commission, 1971, p. 2)

The teaching machines that were developed after Pressey's were used with PI in the following manner:

> A piece of text appeared in the window and a student selected a response or wrote an answer on a blank strip of paper that appeared in another window to the right of the text. When the student gave a correct response, she could turn a crank to scroll to the next segment of text and questions. If the response was wrong, the crank wouldn't operate and the student would try again until she got it right. (Green, 1984, p. 2)

This machine was similar to the one designed by B.F. Skinner, a professor emeritus in the Department of Psychology, Harvard University. But Skinner's machine, and other similar ones, were an improvement over the ones built earlier, such as Pressey's, which were based on a multiple choice test taken after a student had studied the material. With Skinner's machine, the students were taught the material by the machine, not tested. The students did not choose their answers, they composed them. Also, the items were arranged sequentially, so that by correctly answering the items in frame one, he/she was better prepared to move to the next frame, and so on. The theory behind Skinner's machines was described by Gagne:

> Skinner's analysis of instruction assumes that motivation must be present, that the student must make a response, and that this response needs to have consequences which are reinforcing. The increased specificity of Skinner's suggestions center around the principle of stimulus control. (Al-Jaberi, 1984, p. 18)

It was during this time that computer assisted instruction (CAI) systems were developed. This interaction between computer and student was originally called "computer-based instruction". But after IBM, who is considered the originator of the label CAI, stated that these systems were a supportive tool for instruction vice a primary source of instruction, the term "computer assisted instruction" emerged. The original thought behind CAI was that teachers were to be replaced by computers which contained entire courses of study that were in PI format.

During the early 1960s, the development of comprehensive CAI systems based on tutorial dialogue vice PI

was attempted. Due to the cost and the difficulties of designing these dialogues, these attempts became frustrating. In the mid to late 1970s, the capabilities of the computer continued to increase, and the challenge to educators became greater. During this time frame, it was felt by many that

> As this phenomena continues to influence each facet of society, it becomes increasingly important for educators to understand and use the computer to extend the educational capabilities of today's schools. No longer can the education industry afford to allow the fields of engineering and accounting to dominate the computer scene. Educators must develop, within all of their students, the necessary computer literacy and skills that will enable them to accept their responsibility and rightful place in today's computerized society. Such skill-development is a basic requirement for meeting the challenge of getting today's generation of college students ready for its mighty task of leading society into the beginning of the twenty-first century. (Hirschbuhl, 1977, p. 1)

It was felt that CAI would play a big role in facing this challenge. However, many people were very skeptical at the thought of computers and their success in the classroom. They could see its use in the libraries, in medicine, in banks and in other areas of our lives, but they were sure they were doomed to fail in the average classroom. They felt a computer could not allow for nor encourage children to stretch their minds, to try out new ideas or to grapple with problems. They felt it could not come up with activities and responses to suit each child, nor could it know when to encourage, when to prompt, when to provide more information or when to extend the information given. They said there was no way computers could ever replace teachers. But now, ten to fifteen years later, these same people are going into the classrooms of today and seeing how the computer can revolutionize learning in the classroom. (Hancock, 1983, p. 167) They see that

> With a computer children can take care of their learning. Instead of merely being the recipient of information and the responder to instructions, each child can initiate a task, propose solutions, select the preferred alternative and see confirmation of it without having to wait for a teacher's direction, assistance or response. Children can become masters of their own learning. (Hancock, 1983, p. 168)

Since the early 1960s, when IBM developed the first CAI authoring language, Coursewriter I, many authoring systems have rapidly followed, including: TUTOR, which was developed for the PLATO (Programmed Logic for Automated Teaching Operation) system in the late 1960s; DECAL, developed by Digital Equipment Corporation, and PHOENIX, a program which was developed in the 1970s to create and manage CAI tutorials. From the development of these and other programs which were designed to use computers in order to enhance learning, a marked increase in educational computer use has occurred. (Ash, 1985, p. 1) For example, by 1980, approximately 22,000 public schools provided interactive computer instruction, this figure representing 50 percent of all secondary schools, 14 percent of all elementary schools and 19 percent of all other types of schools. In addition, by 1981, approximately 52,000 computers were accessible to the 46 million students who attended kindergarten through twelfth grade (K-12) in either public or private schools. (Ash, 1985, p. 1) It is estimated that the number of computers available for instructional use in K-12 classrooms swelled to 291,000 in June 1983, and to 1,075,000 in June 1985. It is predicted that this number will increase to 2,400,000 by June 1988, and by 1989, there will be one computer for every 15 students, as compared to the ratio of 1:40 in August 1986. (The National Task Force on Educational Technology, 1986, p. 62).

Computer Assisted Instruction (CAI) has been poked and probed and studied since it came into existence. One individual who was a major contributor to a number of these studies is Patrick Suppes. He conducted a large number of studies from 1963 to 1968. In one of his well-known studies, Suppes and another researcher at the Institute for Mathematical Studies in the Social Sciences at Stanford University, M. Morningstar, investigated California's and

Mississippi's CAI programs. As a pretest and posttest, the Stanford Achievement Arithmetic Test was given to experimental and control groups. Gains made by both groups were compared and the results were as follows: The California experimental students in grades 3, 4 and 5 showed a significant difference in the gain of mathematical skills over those in the control group. In the Mississippi schools, a significant gain was made in the mathematical skills of the experimental group in grades 1-6. (Yates, 1983, p.55) One point of interest noted by Suppes and Morningstar was the following:

> The results for Mississippi are substantially more impressive than those for California. This is an example of the generally noticed result that CAI drill-and-practice is more effective with students who start below grade level. (Yates, 1983, p. 55)

In 1972, a study of 10,000 elementary students involved in 30 individual experiments, was conducted by J. Vinsonhaler and R. Bass. In the study, traditional instruction, that with a teacher only, was compared to traditional instruction augmented by CAI drill-and-practice. The conclusions of the studies were:

> There appears to be rather strong evidence for the effectiveness of CAI over traditional instruction where effectiveness is measured by standardized achievement tests. (Yates, 1983, p. 55)

Within the past 15 years numerous studies have been conducted regarding the use of CAI in the educational environment. A majority of the results have proved to be favorable towards the use/incorporation of CAI in the classroom. Some of these studies include the following:

- In 1972, Vinsonhaler and Bass reviewed 10 studies and found that students who received CAI in conjunction with traditional instruction had a higher level of performance than those who were in a traditional classroom. (Ash, 1985, p. 14)
- In 1973, Koch found higher test scores for those foreign language and science students who were taught with CAI drill-and-practice than the traditionally taught student. (Ash, 1985, p. 14)

- In 1978, Tsai and Pohl found that those students who received CAI in conjunction with traditional instruction scored higher on final exams than those with traditional instruction only. (Ash, 1985, p. 14)

- In 1979, Smith and Van Feldt found that students receiving CAI produced a higher achievement level in less time than those who received video-taped instruction. (Skinner, M.E., 1986, p. 10)

- In 1979, a military study was conducted by Orlansky and String and found that training time was decreased by 32%. (Skinner, M.E., 1986, p. 11)

- In 1980, Johnson and Plake found that college students learned more about the main library from CAI and tutorial programs than from a tour. (Skinner, M.E., 1986, p. 11)

- In 1981, Kamm found that in 50 tutorials, fewer test retakes were necessary and 12% more students finished a physics course than those with traditional instruction. (Skinner, M.E., 1986, p. 11)

- In 1982, Boysner and Francis found that undergraduate college students who were taught by means of PLATO instruction received an average of seven and one half points more than paper-pencil students. (Skinner, M.E., 1986, pp. 12-13)

- In 1983, A. R. Molnar performed nearly 60 studies and found 10-15% higher achievement in those students who were involved inn a computer-based course over those in the traditional classroom. (Walker and Bergman, 1983, p. 238)

- In 1985, the Air Force found in two studies a 25% and 34% reduction in training time and higher exam scores in the first test. (Dossett and Konczak, 1985, p. 4)

Studies to measure the educational benefit of CAI are continually being undertaken. The results of these studies have been helpful both to educators and software developers.

III. CAI AND ITS COUNTERPARTS

What is Computer Assisted Instruction (CAI)? Like many things in this rapidly changing world we live in, CAI has been defined in numerous ways, some of which include the following:

> Computer Assisted Instruction refers to the use of computers in an inter-active manner where the computer both presents material to and receives, analyzes, and acts upon responses from each student on an individual basis. (Hallworth and Brebner, 1980, p. 11)

or,

> Computer Assisted Instruction is a supplementary classroom tool that helps teachers teach more effectively. It is a system that enables many students and a single teacher to engage in a one-to-one dialogue, using a high-speed digital computer as the communication medium. Because of this, instruction becomes a two-way communication system that enables the teacher to monitor progress and tailor instruction to fit a student's needs. It accomplishes this mighty task by enabling the instructor to deliver an appropriate instructional move at the precise moment when a particular instruction action is needed. (Hirschbuhl, 1977, p. 2)

or, very simply,

> Instruction that is assisted or aided through use of the computer. (Harrod and Ruggles, 1983, p. 3)

But CAI has been confused with its assumed "look-alikes", and, in some instances, this would be easy to do. The following sections will describe some of these "look-alikes", namely: Computer Managed Instruction (CMI); Computer Based Education (CBE), and Computer Assisted Learning (CAL).

Computer Managed Instruction (CMI). Since CAI allowed students to "learn at their own pace," a record-keeping nightmare seemed inevitable. In the late 1960's, computer managed instruction (CMI) systems were developed with the purpose of relieving the teacher of the record keeping and other tasks which were associated with individualized instruction. Since then, CMI systems have evolved into management information systems (MIS) which were designed to

support the management functions/processes that are associated with individualized education programs (Bozeman, 1979, p. 118). There are various management tasks performed by the computer in a CMI system, including:

> ...handling entrance level testing and testing related to student progress during a course; the reference of students to instructional material found outside the computer based on student's performance on a test, and finally, the handling of a final examination. (Leiblum, 1982, p. 130)

With the computer performing these tasks, the student receives feedback; the instructor receives information regarding each student`s progress, as well as a broad overview of performances, either individually or as a group, and the educational process is easier to evaluate.

By 1979, there were five major CMI systems:

1. Program for Learning in Accordance with Needs (PLAN)
2. Wisconsin System for Instructional Management (WIS-SIM)
3. Navy CMI System
4. Managed Instruction with Computer Assistance (MICA)
5. Tracer

Program for Learning in Accordance with Needs (PLAN), created in 1969, was designed to be used with individualized instruction of language arts, mathematics, science and social studies, on a self-paced basis. PLAN can perform the following functions (Bozeman, 1979, p. 121):

1. Identification and achievement level assessment of each student.
2. Identification and recommendation of the quantity of instructional materials needed.
3. Daily status reports of each student and planning sections for teachers and students.
4. Daily instructional objective test scoring.
5. Daily placement testing.
6. Daily PLAN achievement test scoring.
7. Periodic student progress reports.
8. Administrative reports.
9. Weekly summary reports.
10. On-line student progress reports.
11. History of student progress.
12. On-line ordering of additional materials.
13. Development of each student's program of study.
14. Processing of locally developed objectives, independent activities, and courses.

Wisconsin System for Instructional Management (WIS-SIM) was designed to be able to "maximize the educational progress while making efficient use of the available human, material and financial resources" by "improving instructional decision making" (Bozeman, 1979, p. 122). The system's capabilities included the following (Bozeman, 1979, p. 122):

1. Program data base initiation.
2. Student data base initiation.
3. Entering student achievement data.
4. Achievement profiling.
5. Instructional grouping recommendation and implementation.
6. Diagnostic reporting.
7. Student data base maintenance.
8. Monitoring overlap between instructional programs.
9. Data base purging.
10. Curriculum and program evaluation.

It took six years of research and development in order to make the Navy CMI System operational in 1973. Supporting over 6,000 students at various locations, it was said to be the largest computer-based training system in the world.

> The program prescribes a course of study, with testing and evaluation, individually tailored to each student. Each student is provided with lesson guides and assignments for a sequence of instructional modules which may utilize several media. Upon completion of a module, the student is tested, providing additional evaluative data for instruction prescription. (Bozeman, 1979, pp. 123-124)

Managed Instruction with Computer Assistance (MICA) was developed with the intent to

> ...provide support for programs of individualized instruction through replication of the functions carried on by teachers and aides in such programs. The capabilities of MICA include: enrollment, planning, grouping, assigning activities, recording test results,grading tests, complete report capability and attendance. (Bozeman, 1979, pp. 124-125)

Functioning solely as a management device, Tracer

> ...is an instructional support system which may be used with any criterion-referenced or objective-based curriculum. (Bozeman, 1979, p. 125)

Some of its functions included: scoring, reporting and recording tests; reporting progress on each student; creating class status reports; performing diagnostics, and reporting on curriculum evaluation.

It can be clearly seen that CAI and CMI are different, for CAI is student-oriented and CMI, without actually doing the teaching, includes all the applications of the computer which aid the teacher in instructional management. This managerial component does not exist in most CAI systems, so it is possible to say, under the right circumstances, that the teacher manages CAI via CMI. (Leiblum, 1982, pp. 126-130) Simply stated, in CMI

> ...all testing is done via the computer, but learning is directed by other instructional resources, such as lectures, labs and readings. In computer assisted instruction (CAI) all instruction comes from the computer, including text information and visual examples of practice problems. (Canelos and Carney, 1986, p. 298)

Computer Based Education (CBE). When software developers realized that the computer could do most of the record keeping of students' progress in a CAI system, the term "computer based education (CBE)" was used to replace CAI in order to prevent confusion (possibly) and to show that the computer was capable of being the teacher of new material (CAI), the manager of student learning (CMI) and aiding the student in developing new skills by using Computer-Supported Learning Aids (CSLA).

Computer Assisted Learning (CAL). This system includes all aspects in the use of a computer as an aid to learning and/or teaching (Moursund, 1979, pp. 37-38).

While earlier pages described the history of and definition of CAI, an understanding of the "categories" or methodologies of CAI must be obtained. These methodologies include: drill and practice, tutorials, simulations, instructional games and tests. Problem solving, demonstrations and mini-programming for CAI could also be included, but will only be briefly discussed.

Drill and Practice. This area is considered to be the most frequently used in CAI, for it is used to reinforce regular classroom teaching, as much and as often as necessary. Unlike human instructors, computers don't grow

weary. The main objective of drill and practice is to provide

> ...repeated practice on information to encourage fluency, speed of responding, and long-term retention. (Alessi, 1984, p. 148)

This can only be achieved if the student "receives" an item more than once, even if he/she correctly responded the first time. When not correct, the student should receive the item even more frequently.

This drill and practice cycle consists of the following steps:

1. An introductory section, consisting of a title page, a statement of objectives and directions on how to "do" the lesson, is presented to the student.
2. The student selects an item, which could be a question, problem or some other student exercise.
3. This item is presented to the student who then is allowed to formulate a response, either by using a keyboard, joystick, game paddles, touch pens, touch sensitive screens or voice input devices. By using one of these methods, minimal effort is required of the student and his/her interest and motivation is more likely to be maintained.
4. The response is judged. This should be done intelligently, as if the human teacher were doing the judging.
5. Feedback is given. (Alessi, 1984, p. 146) (Refer to Figure 1.)

This cycle is to be repeated until the student decides to terminate or when the student has reached the required criterion of performance. (Alessi, 1984, pp. 148-149)

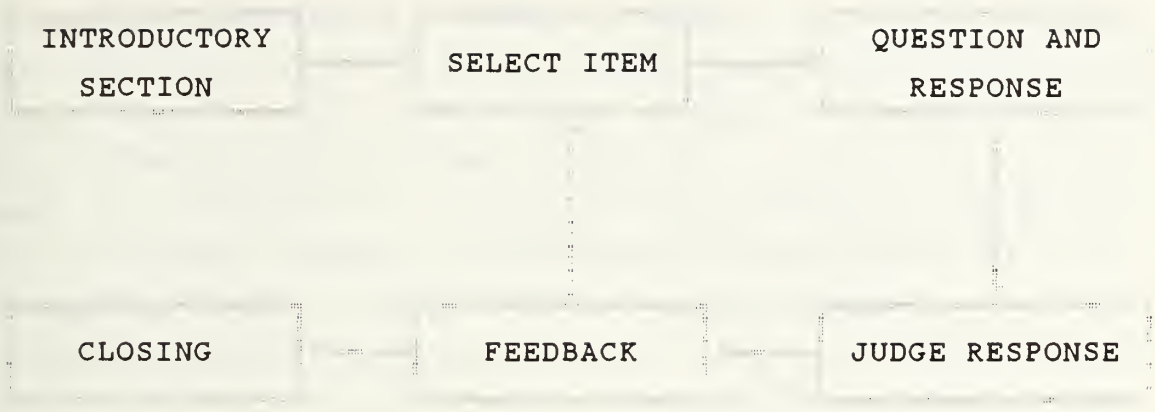

Figure 1. Components of a Drill and Practice. (Alessi, 1984, p. 148)

Tutorial. Drill and practice and tutorials are similar with one important difference. A tutorial can "...stand alone as an instructional entity..." (Harrod and Ruggles, 1983, p. 5), but a drill and practice presents no information, acting as a supplement to classroom teaching or to reinforce lessons learned in a tutorial.

> The tutorial philosophy requires that the program teach rules and concepts, then evaluate the student's comprehension of the concepts and allow practice in the specific skills being taught. (Harrod and Ruggles, 1983, p. 5)

Some of the steps in a tutorial session are very similar to those of the drill and practice, specifically steps 1, 3 and 4. The steps are as follows:

1. An introductory session is presented to the student.
2. Information is presented for the student to read.
3. The student is then to perform some "action" which is required by the information in step two, e.g., answering a question.
4. The response is judged.
5. Based on this judgement, the student receives either corrective feedback or extensive remediation. (Alessi, 1984, pp. 147-148) (Refer to Figure 2.)

The next step depends on if the student answered enough questions correctly (based on the required criterion of

performance) or the student's choice to either move ahead or to receive enrichment material. In either case, the entire cycle of steps 1-5 must be completed in order for the lesson to be effective. If the student decides to temporarily terminate the lesson before completion, the data up to that point is stored so that when he/she returns, directions are given as to how to return to the correct place and how to complete the tutorial. When all material has been covered, the student is informed of the successful completion and is provided directions on how to review the lesson, if this is permitted. This end to a lesson is called a permanent termination. (Alessi, 1984, pp. 147-148)

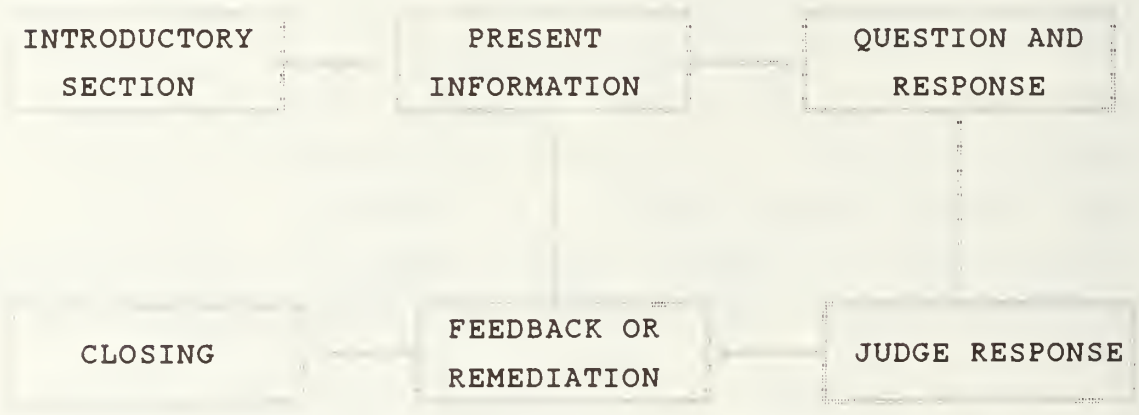

Figure 2. Components of a Tutorial. (Alessi, 1984, p. 147)

Simulation. Being more complex than tutorials, simulations

> ...should be used when basic concepts and principles are being learned. They must be meaningful problems. Simulations can teach specific materials, but their real educational power comes from their capacity to teach about inquiry or problem solving. (Harrod and Ruggles, 1983, p. 5)

There is little similarity between the steps involved in drill and practice and tutorials and those in simulation, as can be seen in the following steps:

1. The introductory section is presented to the student. This is a very important step, for the directions must be clear and concise in order to allow for the variations in student activities.
2. The phenomenon, usually objects, people or events, is presented either by a description or pictorially.
3. The student is required to make an action.
4. The action is made.
5. Internal changes occur in the system, based on this action. (This is done similarly to the judging of a response.)
6. Due to these changes, the description or picture of the phenomenon changes. (Alessi, 1984, pp. 149-150) (Refer to Figure 3.)

Steps 2-6 of this cycle repeat until either the simulation is terminated by the student, or the simulation is either successfully or unsuccessfully completed. This is visually indicated to the student. If the student terminated the simulation, information is given as to how to return to the simulation, if so desired at a later time.

Simulations can only be successful if a proper level of fidelity exists, meaning how closely the real phenomenon, or reality, is imitated by the simulation. However, for the student who is just beginning, a simplified version of the reality is easier to comprehend and control. As the student becomes better acquainted with simulations, the fidelity will increase. (Alessi, 1984, pp. 149-150)

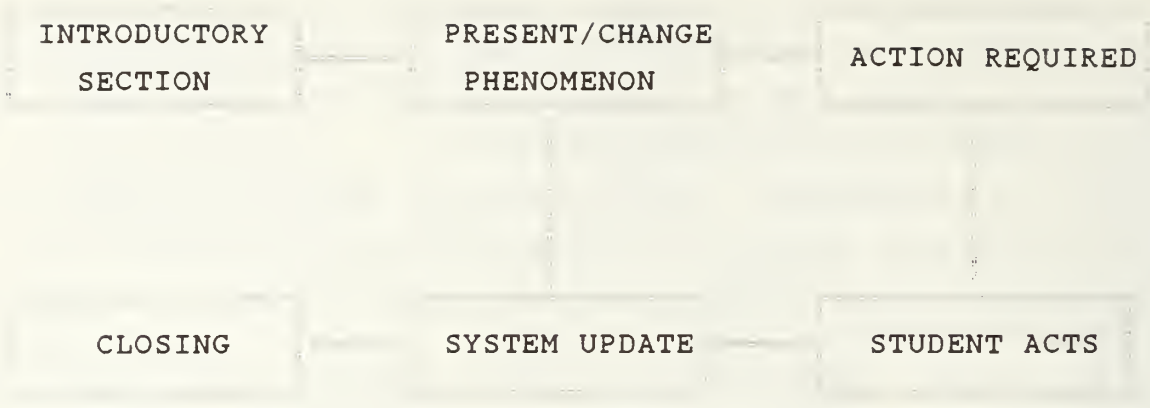

Figure 3. Components of a Simulation (Alessi, 1984, p. 149)

Instructional Games. The main difference between instructional games and simulations is, in some cases, the addition of another person or persons, and the competition that takes place between them. Specifically,

> Instructional games, or "gaming," are situational programs in which a student has to know certain facts, be able to perform certain skills, and demonstrate mastery of specific concepts. ... (Harrod and Ruggles, 1983, p. 5)

The fact that instructional games are more engaging, thus encouraging the student to continue to use them longer, is the advantage they have over other forms of instructions. The student is allowed to "win" the game by achieving the instructional goals, hopefully without cheating or tricking the system. If the latter occurs, accomplishment of these goals will not occur.

The steps involved in instructional games are as follows:

1. The introductory section is presented the student or students. This is a very important step, for in addition to the administrative information given, the rules of the game are explained.
2. A current scenario is presented either by a description or pictorially.
3. The student is required to make an action.

4. The student or the opponent acts.
5. The system is updated due to the action made.
6. The "changed" scenario is presented to the student and the opponent. (Allesi, 1984, p. 149-150) (Refer to Figure 4.)

Upon completion of the game, the closing will announce the outcome or the winner (Alessi, 1984, p. 150).

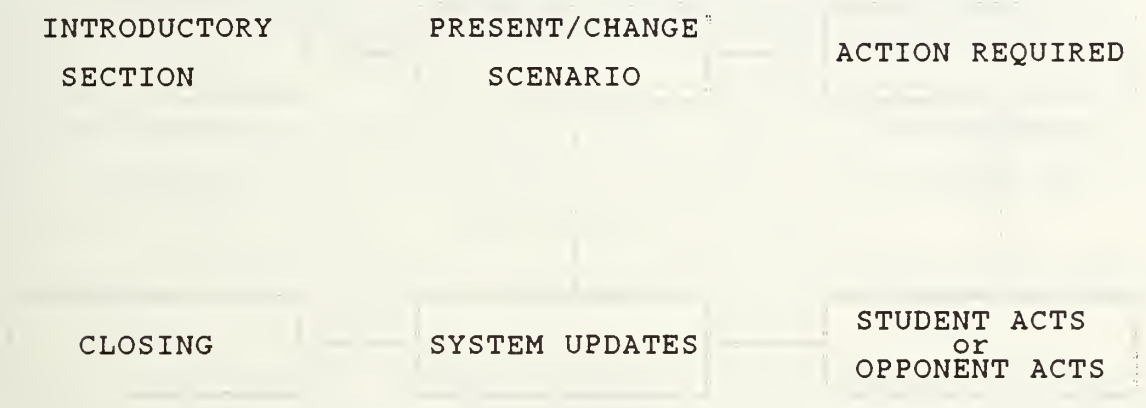

Figure 4. Components of an Instructional Game. (Alessi, 1984, p. 150)

Computer-Based Tests. It must be noted that tests are only as good as the questions they contain. (Allessi, 1984, p. 151) Unless the student desires to view it again, an item is only shown once during the test, and feedback is provided only at the end of the test, not after the separate items. The only time this is done differently is if the test is being used for practice. The steps involved in computer-based tests are, as will be seen, similar to drill and practice:

1. An introductory section is presented to the student, explaining the directions for the test, as well as the other administrative items.
2. An item is selected.
3. A question is asked and the student gives a response.
4. The response is judged.

5. If it is a practice test, feedback is given to the student. If the test is being used for assessment, the next item will be selected. (Allesi, 1984, p. 151) (Refer to Figure 5.)

During this evolution, the student will be allowed to (Alessi, 1984, p. 151):

- ...skip items and return to them later,
- mark items for review (whether or not they are answered),
- reread the directions at any time, (and)
- change their answers as often as they wish.

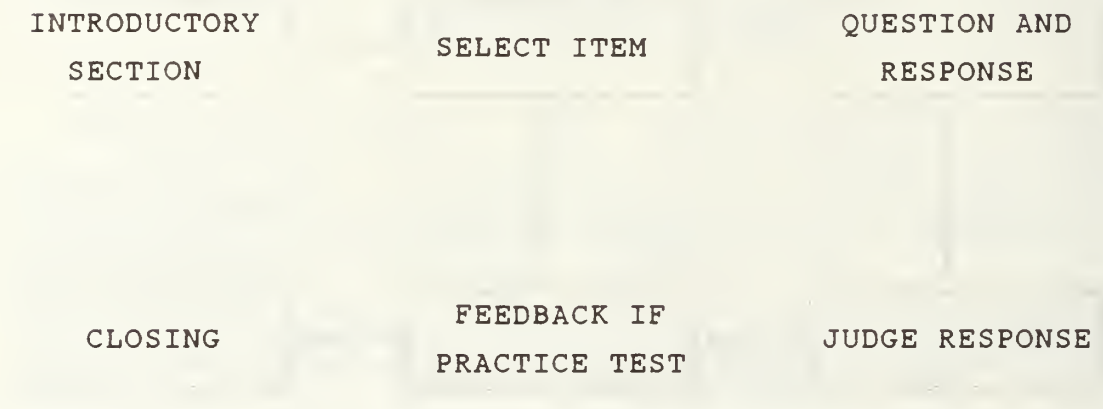

Figure 5. Components of Computer-Based Tests. (Alessi, 1984, p. 151)

Problem Solving. In problem solving, rules which have already been learned, are combined in order to form a new and higher rule which can be used to solve the problem.

Demonstration. In order to explain a certain concept to the student, a visual presentation (demonstration) is generated.

Mini-Programming for CAI. If a teacher desires to create a CAI program, e.g., crossword puzzles or wordsearches, in order to assist his/her students in learning the material, these mini-programs provide short examples and tutorials in order to assist the teacher.

The teacher is not restricted to use only one of the methodologies when presenting a lesson. They can be combined, only if they are used in the proper order (a tutorial before a test) and if they are used in a series of lessons, not all at once. In addition, CAI lessons can be combined with other instructional activities, e.g., lectures, field trips, workbooks, etc..

Advantages and Disadvantages of CAI. Along with everything else, there are pros and cons - advantages and disadvantages - that have been cited for computer assisted instruction. In the December 1982 issue of "The Computing Teacher", Richard Ricciardi, a math specialist, wrote a Letter to the Editor, stating the following:

> Using the microcomputer for drill and practice fosters results even greater perhaps than proficiency at basic facts and operations.
>
> It promotes positive self-image, confidence, satisfaction of achievement, perseverance, and provides immediate reinforcement and reward, all in a non-threatening learning environment. These are the real benefits to the student and perhaps the most important.
>
> The interaction that takes place between computer and student is educationally exciting and fosters much needed motivation for ordinarily humdrum memorizing and practice.
>
> It has been my pleasure to observe this exchange take place daily in my remedial math classes. The students are no longer threatened by classroom competitiveness. They enjoy charting their progress and competing for awards for their individual and group achievements.
>
> Yes, drill and practice truly does have a place in microcomputer education - a place of honor. (Yates, 1983, p. 57)

Based on numerous military and civilian studies done world-wide, other advantages have been stated for using CAI.

1. Individualization of Instruction. This can be done in many different ways, including: an individualization of pace, where each student works through lessons/exercises at different rates; an individualization of response, where each response by each student is handled differently; an individualization of the level of feedback given when the student makes an error; an individualization of the

different skills possessed by each student, and other ways.

2. Savings in Instructional Time. Studies have found that CAI

   ...generally requires less time than traditional methods to teach the same amount of material ... with no loss in post-instructional achievement performance. (U.S. Civil Service Commission, 1971, p. 3)

3. Safety and Expediency of Instruction. In science classes, laboratory experiments can be greatly shortened and the dangers of fire, explosions, etc., can be eliminated.
4. Record Keeping Ability. Individual and group performance records are able to be maintained, as well as, reoccurring problems in courses. This keys the instructor to examine these areas and to revise the question or the entire module.
5. Increased Instructor Effectiveness. Since the majority of the administrative functions, as well as, some of the academic functions have been "taken over" by the computer, the instructor can spend more time on the unique problems of the students and doing some of those "extras" he/she never would have had time for prior to CAI.
6. Increased Quality of Training. Since the teaching community, like all others, has its "bad apples," some students do not receive good instruction. With CAI, <u>all</u> students will be fortunate enough to have a good instructor - the computer!

It has been said that with every "good" there can exist a "bad" and CAI does not differ from this thought, for it has some disadvantages which are either a result of the state of the art of CAI or those which are inherent in CAI itself (Hirschbuhl, 1977, p. 20).

State of the Art Disadvantages.

1. Software/Courseware. In the early to mid-1970s, the lack of available, off-the-shelf software was a problem. This has diminished over the years as more and more software companies are "coming to the rescue." The current problem is that the software must be maintained and continually updated. This is becoming increasingly difficult and costly.
2. Personnel. It takes a team of individuals, not just one person, to develop software for CAI systems. This team could consist of an author, instructional programmer, audiovisual expert, behavioral scientist and many others. These types of individuals are often not found on the staff, so they must be recruited either on a full-time or on a part-time basis.

Inherent Disadvantages.

1. Cost. There are basically two general categories of costs, CAI systems costs and program development costs. These are broken down in the following outline. (U.S. Civil Service Commission, 1971, pp. 5-6)

I. CAI Systems Costs

A. Capital development costs -- this includes the hardware, installation and facilities.
B. Continuing costs -- this category includes those costs which require periodic outlay of funds such as: system maintenance; operations, such as cooling, humidity control, and electricity; program adaptation and maintenance -- which requires personnel and materials to update and modify courses; overhead and supplies.

II. Program Development Costs

A. Course material preparation.
B. Course implementation and debugging (categories A and B include the salaries of programmers, coders, analysts).
C. Training aids.
D. Overhead.

In 1977, John J. Hirschbuhl said that choosing CAI was a "good decision." He also said that

> ...the inherent disadvantages (of the costs of CAI) are overcome by the fact that, given the condition that conventional instruction costs (teacher's salaries, utilities, textbooks, etc.) will continue to rise as

they have over the past ten years and CAI costs continue to drop as they have over the past ten years, then the costs of CAI on a per-pupil basis should be less than half the cost of comparable conventional instruction by 1981. (Hirschbuhl, 1977, pp. 25-26)

2. Time. In 1971, this was considered to be a disadvantage. For example, the U.S. Naval Academy spent between 45 and 350 hours of author time and between 120 and 625 hours of programming time, per CAI hour of instruction (U.S. Civil Service Commission, 1971, p. 7). At that time, CAI was relatively new, but today, those hours have drastically been reduced.

Now that some of the advantages and disadvantages of CAI have been pointed out, a question arises: "Is CAI cost effective?" In order to answer this question, two categories, assets and liabilities, must be listed. (Hirschbuhl, 1977, p. 26)

ASSETS	LIABILITIES
1. Lowering of Student Attrition Rate.	1. Software Development.
2. Individualizing of Maintenance.	2. Continued Instruction.
3. Increased Student and Faculty Performance.	3. Limited Availability of Courseware.
4. Savings in Student and Instructor Time.	4. Lack of Definitive Data of CAI's Optimal Utilization and Limits for Expectations.
5. Increased Teacher Productivity.	5. Short supply of Trained Professionals in the Field of CAI.
6. Staff Savings.	6. Initial out of Pocket Expenses.
7. On demand availability of documented student performance.	

After reviewing these lists, policy makers must decide if effective education is an expense or an investment and if saving money means more than saving students.

IV. THE COST OF HARDWARE AND SOFTWARE

Many factors have influenced the use of computers as an instructional device. Some of these factors relate to the hardware and software required and their associated cost. This chapter deals with the cost of hardware and software but is not intended to provide a cost/benefit analysis of CAI materials. Its purpose is to present collected data in a form which shows the change over time of these costs. In presenting the information however, certain aspects of a historical nature required mention. This was necessary in order to adequately describe certain hardware or software items as well as the factors which influenced the item's cost. Additionally, no attempt has been made, unless specifically described as such, to equate dollar figures to a common baseline or particular year. In some instances, the mathematics of calculating system costs in some literature sources reflects an inadequately defined process. Those cases are so annotated.

A. HARDWARE COSTS

Many claims were made by the early proponents of CAI. These included the computer's ability to free the teacher from routine tasks and its function as a tireless tutor, examiner and scheduler for students. Irrespective of these claims, one factor which has concerned educators from the beginnings of CAI until more recent times has been the exorbitant cost of hardware.

Since the credit for defining CAI has been attributed to IBM, a logical starting place would be to examine their early CAI-related hardware. Having conducted considerable research through their Computer Teaching Machine Project (Coulson, 1962, pp. 171-190), IBM introduced, in 1967, a limited version of an instructional system, the IBM 1500

(Mitzel, 1974, p. 74). Although this computer was designed specifically for computer-based instruction, only 25 were produced. The IBM 1500 was recognized as the most predominant type of computer in use in 1969 and the outright purchase cost just for 32 terminals was over $100,000 with a rental cost of a complete CAI system ranging from $8000 to $12,000 per month (Dick, 1969, p. 12). Whether or not these figures included maintenance fees could not be determined from the sources reviewed.

The IBM 1500 computer, later updated to the 1800 version, with 25 student terminals was introduced at the United States Naval Academy during 1967-1969. Cost data for this particular system revealed that rental for the computer and various undescribed peripherals was $6500 per month, while the rental fee for the 25 terminals was an additional $7500 per month (U.S. Civil Service Commission, 1971, pp. 10, 17).

Other types of computers were also available and in use during the late 1960 to early 1970 timeframe. Not all of these systems were dedicated to CAI as was the IBM 1500.

Some computers, which schools had previoulsy purchased to perform administrative functions, were adapted, through hardware additions, for CAI use. In many of these schools however, their use for CAI was to be on a not-to-interfere basis with the administrative functions. This type of scenario was not very conducive to furthering interest in CAI, but was the best that some school systems could afford. In other instances, the school's computer was capable of time-sharing, therefore administrative and CAI uses could occur simultaneously. Time-sharing is defined as:

> ...a technique or system for supplying computing services to a number of users at geographically scattered terminals, providing rapid responses so that each user appears to be the only one using the system. (Bohl, 1984, p. 557)

This was an important concept in furthering the

implementation and use of CAI because in essence, it made a single computer available to more than one user at a time.

The following section will therefore briefly describe some of the contemporaneous systems to the IBM 1500 so that a frame of reference can be established regarding the cost of hardware in the early stages of CAI. The internal storage limit of the computers has been provided in order to build on the hardware frame of reference for later issues in this and a subsequent chapter.

Systems which could be dedicated to CAI included (Lynch, 1971, p. 59):

- the Honeywell 1648, which was capable of supporting up to 48 terminals;
- the IBM System 360 Model 65 (360/65), which was capable of supporting up to 160 terminals, and,
- the RCA Spectra 70/45, which came in two configurations, one capable of supporting up to 48 terminals (70/45-48) and the other of up to 192 terminals (70/45-192).

The maximum size of some of these systems indicates a marketing strategy aimed at the college or university level.

Systems capable of being used simultaneously for administrative and CAI uses included (Lynch, 1971, pp. 50, 57-58):

- the IBM System 360 Model 30 (360/30), capable of supporting a maximum of 4 terminals;
- the GE Time Sharing 255, capable of supporting a maximum of 10 terminals, and,
- the GE Time Sharing 275, capable of supporting a maximum of 24 terminals.

In terms of a market, time-sharing computers broadened the range of potential users.

Since each of these systems varies in its maximun terminal capacity, Tables 1 and 2 are provided in order to show a hardware cost comparison based on a 4-, 10- and 16-terminal configuration (Lynch, 1971, pp. 116, 121-122, 157, 162, 171-172, 191-192). The cost for maintenance and operator personnel salaries for these system configurations has not been included due to an unsubstantiated method for their calculation in the literature source cited.

TABLE 1. SYSTEMS CAPABLE OF DEDICATION TO CAI

System Description	Cost in Dollars as Configured for "x" Number of Terminals		
	4	10	16
IBM 360/65 with 524K storage	2,028,000	2,080,500	2,133,000
Honeywell 1648 with 64K storage	432,000	444,000	456,000
RCA Spectra 70/45-48 with 65K storage	851,000	863,000	875,000
RCA Spectra 70/45-192 with 256K storage	1,273,000	1,285,000	1,297,000

TABLE 2. SYSTEMS CAPABLE OF TIME-SHARING

System Description	Cost in Dollars as Configured for "x" Number of Terminals		
	4	10	16
IBM 360/30 with 65K storage	530,000	NA	NA
GE 255 with 32K storage	314,000	338,000	NA
GE 275 with 32K storage	551,000	575,000	599,000

As can be seen by comparing the dedicated CAI systems with one another, the cost differential for similarly equipped systems is significant. When comparing the time-sharing systems however, the difference in cost among systems is much less. Although the expandability of a dedicated system is a major point in its favor, the ability to perform both school administrative and CAI functions on a time-shared basis and at a much reduced cost over a dedicated system was attractive to many educators. CAI moved within the window of affordability of more schools due to the time-sharing ability of certain computers.

It must be kept in mind that a large majority of a school's budget is spent, for all practical purposes, as soon as the budget is approved. According to a paper

presented before a 1974 National Institute of Education conference:

> School systems characteristically allocate 80-90 percent of their operating budgets to personnel costs associated with instruction. After taking out costs such as debt reduction and physical plant maintenance, there are practically no degrees of freedom. ...the purchase of a million-dollar computer for a school organization with a $15,000,000 annual operating budget is 8.5 percent of the $12,000,000 already committed to teaching personnel on a continuous basis. (Mitzel, 1974, p. 75)

What was also occurring during the late 1960 to early 1970 timeframe was the development of another dedicated CAI system. This system was designed to fill the void that existed regarding terminals designed for instruction. Most early CAI terminals consisted of what is called a TTY (teletype) terminal, which is a keyboard and printer combination. This new CAI system was known as PLATO, an acronym for Programmed Logic for Automatic Teaching Operations. It consisted of a minicomputer and terminals with touch-sensitive video screens and a superior graphics capability. The PLATO project was developed at the University of Illinois under the sponsorship of Control Data Corporation and funded by the National Science Foundation.

The concept of PLATO was to implement CAI on a very large time-sharing computer and be able to spread the terminals out over a sizeable geographic area. In this manner, one site could contain the computer and a few terminals, and the remaining terminals would be in outlying areas. It was envisioned that this capability would be beneficial to many school districts. By 1981, there were 19 PLATO systems, consisting of 8000 terminals, throughout the world with Control Data Corporation owning and operating 11 such systems and various universities the remaining eight (Poore and Hamblen, 1984, p. 46). Cost however prohibited many other schools from obtaining PLATO services. In 1980, a PLATO terminal cost $10,000 and approximately $800 per month in useage fees (Braun, 1980, p. 110). The cost of the

computer could not be determined from the literature sources reviewed.

In lieu of a system purchase, Control Data Corporation also offered schools a package of services called ED-PAK, which consisted of eight terminals, all related communication equipment, line charges, maintenance, lesson royalties, computer use charges and staff training for a cost of $54,000 per year in 1979-1980 (Poore and Hamblen, 1984, p. 49). Considering a purchase price of $80,000 for eight terminals, the ED-PAK offer represented considerable savings. This concept was taken one step further by Florida State University (FSU), which operated its own 200-terminal PLATO system. "FSU offered the equivalent of an ED-PAK to public schools in Florida at the University's cost of $44,259 per year." (Poore and Hamblen, p. 49)

From the outside, the FSU offer was very affordable but other cost factors had to be brought into play. These factors relate to the perspective from which costs are viewed. From FSU's perspective, the ED-PAK cost was $44,259. From the school principal's view, the ED-PAK cost had to be raised by $18,838 to a new figure of $63,097 per 180-day school year in order to account for direct instructional costs for personnel salaries and benefits, workbooks, classroom space, desks and other expenses (Poore and Hamblen, 1984, p. 49). From the view of the Florida Department of Education, which used a complicated calculation method based on terminal useage, administrative costs, loss of opportunity cost [i.e., the amount of interest that could be obtained if the money were instead invested at some specified rate of return] and other indirect costs, the yearly cost for the PLATO ED-PAK was as follows (Poore and Hamblen, 1984, p. 49):

- eight terminals used five hours per day: $80,455.
- eight terminals used eight hours per day: $95,052.

The point of bringing out these different views regarding the cost of implementing CAI is that traditional methods of cost calculation with regard to educational technology do not always reflect an accurate picture. There are other factors which must be considered as well. Some of these are illuminated by the following:

> The basic structure of school financing and the lack of reasonable productivity measures combine to make the systematic introduction of new technology into the mainstream of public education very difficult.
>
> Models of school financing do not provide for capitalizing technology by trading off technological expertise against personal services, or for the combining of the two. ...Productivity measures are head-count and seat-time oriented. They do not reflect the cost in subsequent grades of a child's failing to master material in an earlier grade; nor the cost of wasting the time of a gifted child; nor the cost of the loss of a high quality teacher because of an unresponsive school system. (Poore and Hamblen, 1984, p. 45)

Although the falling hardware cost of the larger dedicated and time-shared CAI systems encouraged more schools to incorporate CAI into the curriculum, the arrival of the microcomputer in the 1975-1977 time frame brought affordability to nearly every school. In 1980, a typical microcomputer system's cost was $500 to $2500 depending on which peripheral devices were purchased with it (Braun, 1980, p. 110). The capability of microcomputers as an educational device was capitalized on by several companies such as Apple, which by 1984, had given away over 9000 computers to California schools, and IBM, which had donated over 1500 computers to schools in New York, Florida and California (Bonner, 1984, pp. 68-69).

One cost study, published in 1984, reflected the breakdown of cost into hardware and software components required to furnish CAI to a school of 750 to 1000 students. The results of this study (Pressman and Rosenbloom, 1984, p. 97) showed:

- that a CAI system consisting of 15 microcomputers, each with 48K memory and a color monitor, plus two printers, various types of prepackaged software, installation as well as training and maintenance costs would total $98,550;

- that when prorated over an arbitrarily determined seven year period, to include a ten percent cost overrun and a yearly interest charge, the adjusted average yearly cost was $17,360, and,
- that 750 students using the computer for one-half hour per week for 35 school weeks resulted in a $1.32 average CAI cost per student hour.

As technology improved, the capability of microcomputers increased and the price has continued to fall. Today, a very capable microcomputer system with a monochrome monitor, keyboard, 360K floppy disk drive, 20 megabyte hard disk and 640K memory can be purchased for under $1000. The cost of hardware is no longer an obstacle to the implementation of CAI.

B. SOFTWARE COSTS

The initial software offerings for CAI reflected nothing more than the adaptation of programmed instruction texts in such a way as to enable the computer to present the instruction frames. The cost of converting text from a programmed instruction manual to a form capable of display by a computer could not be determined from the literature sources reviewed. It is assumed that this cost was minimal. The resultant effect of this adaptive effort however, was negligible as far as furthering CAI was concerned. It was much cheaper to retain a textbook approach to programmed instruction as opposed to purchasing an enormously expensive computer simply to turn pages.

The introduction of CAI into the Naval Academy in the late 1960s does shed some light on early educational software development. Although dollar figures are not given, a case study published in 1971 does provide the following information (U.S. Civil Service Commission, 1971, pp. 10, 14, 15):

- four CAI courses were developed: Physics, General Chemistry, Russian and Naval Operations.
- the total amount of CAI instruction varied from 12 to 33 percent per course.
- each CAI course had several authors, none of whom had previous CAI experience. Instruction was given to each regarding CAI.

- author preparation time for one hour of tutorial material in upper division science ranged up to approximately 350 hours while one hour of Naval Operations Analysis required approximately 45 hours.
- programming time varied from course to course. Physics required 10,000 hours, Russian 1800 hours, Naval Operations 400 hours and Chemistry 2500 hours.
- programming time per instructional hour ranged from 40 to 555 hours.
- the CAI courses also used graphics and filmstrips. The turnaround time from author to finished product was two months with regard to these types of items.

By summing the lows and highs of the authorship and programming times, a range of 85 to 905 hours per instructional hour results. The complexity and duration of the particular course obviously had an effect on the overall amount of time required to develop and program the various CAI lessons.

While U.S. government funds were being used for the Naval Academy's CAI project, most of the other schools in the United States could not afford such an expense for CAI. The level of CAI useage was low nationwide.

> National Education Association data for the year 1974 show that 11.6 percent of secondary schools and 3.9 percent of elementary schools use some form of CAI,.... (Baker, 1978, p. 16)

Without an established and sizeable hardware base, few companies were interested in producing educational software. What did occur was software authorship by a small group of teachers, most of whom worked independently, and whose school had one or more computers. Cost figures for these instances were not located and in all likelihood may not exist since these teachers worked mostly on their own to develop programs for their students' use.

The arrival of the microcomputer sparked a greater interest in software development by several companies. The drawback though, was that most of the microcomputers in schools were 8-bit computers with 64K of memory. This limited the complexity of the programs. In spite of this, it is possible to create high quality educational software, but at a substantial price. Estimates range from up to

$500,000 for a simulation program to $1-1.5 million for a semester to year long computer aided course (Ploch, 1986, p. 47).

A recently published information pamphlet by the U.S. Air Force showed that CAI development hours per hour of instruction ranged from 100 to 400 hours at a cost for development of $5000 to $20,000 per hour of instruction (Brewer, 1987, p. 8). A course consisting of only a few hours of instruction could require a substantial investment in software development.

C. SUMMARY

It is quite evident that over the past two decades, the cost of hardware has continued to fall while the cost of software has continued to rise. While these trends may continue into the future, more emphasis must be placed on the development of high quality software. The next chapter examines this topic.

V. THE INTERACTION OF EDUCATORS AND SOFTWARE DEVELOPERS

A. SOFTWARE AVAILABILITY AND ADEQUACY

One problem which has plagued the use of computers in education from the beginning has been related to the availability and adequacy of software. When the movement to introduce computers into the educational environment began in the 1950s, the initial problem was one of a lack of software. Several actions were taken in an attempt to remedy this situation. Since programmed instruction was considered at that time to be the wave of the future, one action was for textbook publishers to adapt their programmed instruction materials for computer use. Some of these efforts however, merely resulted in the use of the computer as an electronic page turner by providing a book format on the screen without any additional advantages (Pressman and Rosenbloom, 1984, p. 95). Other actions included the writing of educational programs by both full time programmers and by educators who had learned how to program. Not all of these efforts, including those produced by educators, were beneficial due to their rudimentary style of presentation and narrow scope. While these beginning steps in the fledgling process of utilizing computers in education did result in bringing the computer into the classroom, they did not result in the wide spread acceptance and use of computers that was expected.

There are many issues that relate to why less-than-enthusiastic acceptance resulted. Not all of these issues relate specifically to the software issue, but as a whole, they portray an approach or an attitude toward computers in education that has affected the development of software. These issues must be described before proceeding on to the

issue of interaction between educators and software developers.

1. A Continuing Myth

There exists even today a belief by some educators that the use of computers in schools will result in reducing the number of teachers required. Early purveyors for the use of computers in schools had stated that many tasks performed by teachers were of such a routine nature that they were best suited for accomplishment by a computer. No evidence was located in the literature sources reviewed to substantiate that any teacher had been replaced by a computer.

2. A Lack of Hardware

As was discussed previously in the chapter dealing with the cost of hardware and software, the cost of hardware, while initially at a high level, has been reduced considerably. This has been due to advances in technology and manufacturing, as well as competition in the marketplace and other factors. History has shown the hardware progress from that of expensive mainframes and minicomputers to the mid-1970s introduction of the cheaper microcomputers, which have come to also be known as personal computers. While this reduction in cost has enabled more schools and school districts to be able to afford computer hardware, there still exists a low ratio regarding number of students to computers in our public schools. The following excerpt reflects on the hardware shortage:

> The number of personal computers for instructional use in public elementary and secondary schools has risen from 31,000 in 1981 to 325,000 in 1983 and is expected to double in each of the next five years, reports the National Center for Educational Statistics. (Bonner, 1984, p. 64)

While arguing before the U.S. House of Representatives Subcommittee on Science, Research and Technology in 1984 with reference to his introduction of the

Computer Literacy Act of 1984, Representative Timothy E. Wirth stated,

> There are only 325,000 computers for America's 40 million public school students, roughly one computer for every 123 students. If every child in our schools was to be provided 30 minutes a day on computers, we would need four million (computers) in our schools, 12 times the actual number. (Bonner, 1984, p. 72)

This viewpoint by Representative Wirth was supported by Harry A. McQuillen, President of CBS Educational and Professional Publishing who stated,

> We estimate that by the end of 1984 nearly 400,000 microcomputers will be in our elementary and secondary schools. On the surface this seems like a large number and suggests dramatic progress. However, these micros are heavily concentrated in more affluent school districts and projections show that we will not achieve a ratio of 30 students per computer until 1987.... (Bonner, 1984, p. 72)

According to information published more recently, Quality Education Data (QED), a market research firm, reported that, "...U.S. schools have bought only one computer for every 50 students--about 750,000 machines...." (Ploch, 1986, p. 44) Similarly corroborating information was recently provided to the U.S. Secretary of Education as addressed by the following:

> A market research firm estimates that the number of computers in K-12 classrooms increased from 291,000 in June 1983 to 1,075,000 by June 1985, and will further increase to 2,400,000 by June 1988.
>
> At present, there is, on average, one personal computer for every 40 students in the public schools. The projected installed base of 2.8 million computers in 1989 represents an average of one computer for every 15 students, still a fairly high ratio. This ratio needs to be further decreased, particularly in environments that emphasize subject-matter mastery for each student. (The National Task Force on Educational Technology, 1986, p. 62)

The report to the Secretary of Education went on to recommend a continued hardware acquisition plan. The specific recommendation was: "One workstation for every ten students is an achievable goal and an important step in the right direction." (The National Task Force on Educational Technology, 1986, p. 62)

3. Optimality of Hardware

Although the figures show an increase over the years in the number of computers in the nation's schools, it is worth noting that most of the computers in our schools are microcomputers. A closer examination of what types of microcomputers are being placed in classrooms is necessary. "According to QED, more than 55% of schools own Apple computers (most of them in the Apple II family), 17% own Radio Shack models and 13% own Commodores." (Ploch, 1986, p. 44)

These particular computers were first introduced during the 1977-1979 time frame and one factor which has made them so popular is their relatively low cost. While this factor may be sufficient from a relatively casual perspective to justify a purchase, a more important factor is often overlooked. This relates to the available random access memory (RAM) of these computers and their use of an 8-bit microprocessor. Since the majority of these microcomputers have a memory (RAM) limited to 64 kilobytes (64K), they are restricted in their ability to handle complex educational software. The combined effect of having a 64K memory and an 8-bit microprocessor results in the slower running of programs, constraints on the sophistication of graphics, as well as, constraints on the size of the software package. This is not necessarily the case with the 16- and 32-bit microprocessor-based computers on the market today. This was best summed up in a recent article:

> As a result, the older microcomputers are often used with simpler, less creative education programs or with general-purpose productivity tools that were not specifically designed for school use. (Ploch, 1986, pp. 44-45)

On the other hand, at the time these particular computers were introduced, the volume of educational software in the market was at a lower level than it is today. The main point here is that while the previously

mentioned computers may have been adequate several years ago, their limited memory and other factors limit their capability with regard to educational software. It should also be noted that each of the previously mentioned computer manufacturers have available on today's market 16-bit, and, in some cases, 32-bit computers.

4. The Distribution of Available Hardware

Even though the ratio of the number of students to computer has been shown to be decreasing when viewing our educational system as a whole, there are other items which affect the availability of computers in the classroom. One of these items relates to the inequitable distribution of computers among the nation's public schools. In giving testimony before a U.S. House of Representatives subcommittee in 1984, a spokesperson for the National Education Association (NEA) stated:

> There is a persistent and substantial inequality in the access to new technologies among both schools and school children. In simple terms, the poorer a school is, the less likely that school is to have any of this new technology.
>
> The question of equity of access to school computers is a microcosm of a much larger issue: The necessity to provide access and equity to quality educational experiences for all of our nation's children. We simply cannot allow technology to exacerbate this problem. (Bonner, 1984, p. 77)

The comments made by the NEA representative regarding this inequality are supported by a 1983 Johns Hopkins University survey which stated:

> Public schools in districts with a high percentage of poor families are much less likely to be microcomputer-owning schools. For example, whereas two-thirds of public schools in the better-off districts have microcomputers, only 41 percent of schools in the least wealthy districts have any. (Bonner, 1984, p.77)

As a co-sponsor of the Computer Education Assistance Act of 1984, Senator Robert F. Byrd cited information from a 1983 University of Minnesota study: "The 12,000 wealthiest schools in this country are four times more likely to have microcomputers than the 12,000 poorest." (Bonner, 1984, p. 77) In an attempt to counter the question of equity, a

representative of the Minnesota Educational Computing Corporation, a non-profit corporation established by the State of Minnesota, argued that computers first went into the poorer schools in cities such as Detroit, New York City, Dallas, Los Angeles and Houston. The corporation representative further indicated however, that:

> It's not a socio-economic thing, it's just a teacher awareness, teacher leadership kind of thing. And perhaps lower socio-economic school districts have a weaker set of teachers, in which case there's less likely to have been a natural set of leaders who went out and made computing happen. (Bonner, 1984, p. 77)

It would appear from the preceding quote that socio-economics is indeed a factor in determining the distribution of computers in public schools.

A second item related to the distribution of available hardware centers on the requirement in some schools to schedule the use of their computer resources. This scheduling requirement is necessitated for two reasons. First, there still are not enough computers in our schools so as to provide at least one computer per classroom. Second, in some schools the computer is also used, and in some instances exclusively, to perform administrative office functions.

What occurs as a result is that teachers must schedule use of the computer(s) in advance and, in some cases, physically bring the computer into the classroom for the period of usage. While this matter may appear to be rather inconsequential relative to hardware availability, it none the less has been a contributor to the teacher's attitude toward computers. According to Senator Frank Lautenberg, sponsor of the Computer Education Assistance Act of 1984:

> Although more than half the nation's schools have at least one microcomputer, that is also the most that a large number of these school's have. (Bonner, 1984, p. 64)

According to the NEA:

> Relatively few students get any computer instruction. In most of our schools where computers are present, this

equipment is reserved for administrative uses or for the classes of only one or two teachers--generally those who actually teach computer skills. (Bonner, 1984, p. 64)

In 1982, a study was conducted in which 17 teachers from nine secondary schools used a microcomputer as a teaching aid over an extended period. The following summary reflects the results:

> ...the majority of teachers who took part in the trials are continuing to use the microcomputer as a teaching aid and there is some spread of interest to those who did not participate. The extent to which teachers have continued seems largely to be determined by their ease of access to the computer itself; moving a class to the computer seems easier than moving a computer to a class, but the ideal is to have a computer present all the time. (Phillips and others, 1984, p. 175)

5. Lack of a Coherent Hardware Purchase Plan

The 1985 report to the Secretary of Education by the National Task Force on Educational Technology cited the need to have a well-conceived and on-going planning process at the state, district and school level for the purchase and introduction of hardware and educational software. Information obtained from a 1983 Johns Hopkins University survey states that before 1982,

> ...the initial impetus for obtaining micros often came from a single teacher. ...where a single teacher dominates acquisition and implementation in elementary schools, micros sit idle more often.... (Bonner, 1984, p. 67)

Computers have been placed in schools as a result of fund-raising by the PTA or teachers, donations from manufacturers such as Apple and IBM, special grants and school system funds. Quite often this diversity of procurement methods occurred with little thought to the software required and as a result, less than optimal educational results have been achieved from the perspective of many teachers. Another item related to this is that hardware would at times show up at schools with little or no plan for educating teachers on its use. This situation was addressed again as recently as 1984-1985 by the National Task Force on Educational Technology in a report in which they stated:

> Many individual teachers were supplied with microcomputers without first being convinced about their usefulness or receiving even rudimentary training in their proper application. As a result, the technology was not used as it was originally designed to be. (The National Task Force on Educational Technology, 1986, p. 59)

6. Teacher Literacy and Computer Training

Representative Albert Gore, Jr., the author of the National Educational Software Act of 1984, cited inadequate teacher training regarding how to use computers and plan for their integration into standard coursework as a major obstacle to effective use of computers in education (Bonner, 1984, p. 67). Not all teachers were exposed to computers during their own educational process and many have a fear of computers for a variety of reasons. Others, although lacking formal training regarding computers, have, on their own, developed a working knowledge about computers.

With the proliferation of microcomputers into the home, it's not unusual today to see students exhibit a substantial knowledge concerning computers. This can however, prove detrimental to a classroom in which the teacher does not possess an equal or greater knowledge. Occasionally, as a result, the teacher will not use the computer so as to avoid embarrassment. The National Task Force on Educational Technology has recommended,

> ...that all organizations responsible for pre-service and in-service teacher education design and implement effective programs to prepare teachers to use technology to its best effect for instruction and instructional management. Particular attention should be paid to educating first-year teachers. (The National Task Force on Educational Technology, 1986, p. 64)

7. Initial Approaches to Developing Software

In one of its Training Systems and Technology series publications published in 1971, the Civil Service Commission's Training Assistance Division described existing software as follows:

> The press implies that the heavy investments of Wall Street and of giant new industries have rounded up the brains of the nation, have produced quality programs in quantity, and are ready to move with dispatch into the schools. It was a real shocker to discover how crude and primitive the programs actually are, and how far they are

> from the large-scale integration into the schools or into the educational process in general. (U.S. Civil Service Commission, 1971, p. 4)

What had occurred during the period beginning in the early 1950s and the publishing of the Civil Service Commission's report was the adoption by industry of programmed instruction. In fact, programmed instruction had come into vogue as the way to self-instruction without individual human tutors (Oettinger, 1969, p. 120). What then occurred, as a result of viewing the computer as a tool for adapting instruction to the individual, was to use computers for programmed instruction. This resulted in computers serving as expensive page turners to mimic programmed texts (Oettinger, 1969, p. 181). Even after the arrival of microcomputers in the middle to late 1970s, vendors continued to produce electronic versions of programmed learning texts (Yates, 1983, p. 56). Software producers viewed the computer in education as a marketplace. One author has gone so far as to conclude that advocating microcomputers in education has not come from educators or a response to research documenting its effectiveness, but rather as a result of mass marketing strategies by hardware and software manufacturers (Bear, 1984, p. 11). For whatever the reasons to be cited, it is firmly documented that much of the educational software has earned a bad reputation among users. This can be summed up as follows:

> In their haste to capture their share of the market, these entrepreneurs frequently neglected to consult with anyone having teaching experience before they designed their programs. They often elected to forego any pilot testing (which would take too much time) before they began advertising the product. At the same time, other new programs seemed to be written by teachers who had just learned how to program and wanted to use their newly acquired skills to meet their own classroom needs. While the former type of software reflected good programming skills but poor understanding of how children learn, the latter was characterized by good pedagogy but poor programming skills. (Yates, 1983, p. 56)

8. Choosing the Right Software

Software continues to be produced at a brisk pace and the volume of titles being created has resulted in

problems of choice for educators. One estimate from 1984 indicated that about 70 percent of mathematics software and 95 percent of language arts software were worthless (Otto, 1984, p. 65). Another estimate made in 1984 by a New York City public school official, indicated that his office had identified approximately 200 programs as useful out of the 10,000 that were available (Bonner, 1984, p. 69).

With so many programs to choose from, it is virtually impossible for teachers to evaluate each one. What has occurred however, is the creation of several software review organizations to assist educators. These include: Consumers Union and the Educational Products Information Exchange (EPIE). These two organizations create and circulate rigorous evaluation reports on computer software as well as hardware. The reviews provided by EPIE have been noted for their consistently high standards of impartiality, in-depth analysis and the capacity to match reviewed software with topics such as elementary school math. Other organizations include the Northwest Regional Educational Laboratory, which has a software evaluation project called Microsift, and the National Education Association (NEA). In addition to providing information to schools regarding software reviews, the NEA also publishes, through its Educational Computer Services division, The Yellow Book: A Parent's Guide to Teacher Tested Educational Software. It is worthy of note, that the back cover to the 1985 edition of the NEA publication indicates that only 115 programs were approved by them from the first 1500 tested (National Education Association, 1985, back cover).

B. INTERACTION OF EDUCATORS AND SOFTWARE DEVELOPERS

In spite of the software manufacturers' valid claim regarding the expense of developing educationally sound, high-quality software, more thought is being placed into educational software by them. In some instances, developers

have supplemented their software with documentation describing how to incorporate the programs into regular classroom lessons. In other instances, software companies have formed software development teams consisting of an instructional expert, a subject-area expert, a graphics specialist, a music specialist and a programmer (Ploch, 1986, p. 47). Similarly composed teams were recommended as early as 1971 (U.S. Civil Service Commission, 1971, p. 5). While teams such as these drive up the cost of software, it indicates a commitment on the part of some developers to provide a quality product. In this regard, several companies have established a reputation for quality products in the area of mathematics (Yates, 1983, p. 57). Another positive note is the fact that many major educational publishing houses have begun to produce software and this brings to the production of software a background in education absent in many other software companies (Trimble, 1986, p. 35).

Further actions are required however to increase the interaction between educators and developers. One area that was stressed as early as 1969 in a report by the Committee on Educational Research of the National Academy of Education, was that of calling for more research regarding the computer in education (Cronbach and Suppes, 1969, pp. 150-152). In fact, one of the editors of that report, Patrick Suppes of Stanford University, has conducted considerable research regarding the use of computers in education. His studies with regard to drill and practice have yielded very positive results which have been corroborated by others (Yates, 1983, p. 55).

One area that requires additional research is that of learning theory. Some research questions that have been posed include (Thompson, 1984-1985, p. 14):

1. What are the most effective CAI strategies? What is best in terms of feedback? Are different paradigms better for different areas?

2. How do individual learning styles interact with CAI? How much cognitive complexity can students handle?
3. What are the effects of individual learner characteristics in CAI situations (e.g. memory span, perception, I.Q., motor skills, sensory preferences and literacy levels)?
4. What hardware configurations are most effective, efficient and necessary? How important are audio outputs, touch panels, video capabilities or light pens?
5. How does affect relate to CAI? What are the roles of motivation, persistence, delayed gratification or locus of control?
6. What are the most effective strategies for program development? How should programs and practitioners relate to each other?
7. What are the most effective strategies for integrating CAI with other instructional activities?

In order to adequately answer the above questions, a great deal of research and cooperation between educators and software developers will be required. An ideal starting place could be with existing software which has been evaluated as superior by an independent organization such as EPIE and used in a classroom enviromnent with positive results. The arrival of 16-bit microcomputers into the classroom coupled with the development of high quality educational software should strengthen the recently established link between educators and software developers.

VI. THE FUTURE OF CAI

It was only twenty years ago that parents were sitting at the kitchen table trying to make sense of the "new math" their children were studying in school. The parents were puzzled and dismayed at the fact of their own inability to understand their ten-year-old's homework. But that proved to be only the beginning. Today, we find that the only difference between "yesterday's child" and today's is the tool(s) that they learn with. Yesterday's child, the one who helped his/her parents understand "new math", is seeing his/her children using the computer in their classrooms.

The rate at which computers are being used in schools is rapidly increasing. Today, it is not unusual to have a student go into a programming class like BASIC and be taught how to use a computer by another computer or an instructor, or to study their science, history, math or other subjects via the computer. Another change from "yesterday" is that this learning via the computer does not stop once the child leaves the classroom. Chances are they can take their assignments home and finish them on their home PC, that is, if they can pry their parents away from using it for balancing the family budget or learning Spanish before they take that trip to Mexico or just playing a game!

In 1982, over two million home computers were sold and by 1986, this figure had increased to 10 million. Children can go to computer camps to either learn how to use one or to teach others. Computers are a big "hit" on the college and university campuses today. The United States Naval Academy in Annapolis, Maryland, has one computer for every room in their dormitories. Some colleges and universities are insisting that all incoming students have computers. Students at all levels are demanding to learn more and more

about computers. Congress has had computer-education bills introduced which are aimed at providing access to computer training for every American student over the next 5-7 years. "It is not unrealistic to suggest that computers will soon be as basic to student learning as pencils and papers." (Bohl, 1984, p. 28) One of the leading proponents of computer assisted learning (CAL), Alfred Bork, predicts that by the year 2000, 50% of all instruction that takes place in the United States will be by CAL. (Moursund, 1979, p.38) Some other predictions include (Otto, 1984, p. 60):

- Computer technology will...revolutionize teaching and learning. By 1990, a microcomputer center will exist in nine of ten homes, where much of the basic skills curriculum will be provided. (1974, Nolan Estes, former superintendent of Dallas public schools)
- Reading may loose its place as the primary criterion for academic success, with computer literacy overtaking it as education's number one priority. (May 1982, "The Computer Goes to School", Principle, Sally Zakariya)
- Any predictions we might make, even the wildest surmises, can only be pale shadows of the things to come. (Beverly Cleaver, "Education in the 80's: English)

The question is "How will this continual rise in the use of CAI take place?" As was presented in past chapters, the cost of hardware is continually declining and there is more software/courseware available. More parties, e.g., electronic game manufacturers, software houses, computer manufacturers, and corporate training organizations, are shouldering the costs of developing high quality courseware (Pressman and Rosenbloom, 1984, p. 95). Large corporations, such as CBS, Walt Disney and Reader's Digest, are entering into this field, as are Scott, Foresman and Addison-Wesley, two publishing houses. These are both favorable for the continued and accelerated use of CAI.

Now that more parties are becoming involved in the software production side of the house, is there going to be a need for more software and what criterion should be followed in the development of CAI software? The answer to the first part of the question is "Yes." Between 1982 and

1987, there was a compounded annual growth rate of 75% in the educational software market (in units). In terms of dollars, this same time frame had a compounded annual growth rate of 48%. By 1988, it is estimated that the demand for educational software will exceed one billion dollars. This software consists of graphics, word processing, instructional and authoring systems used for in-house production of CAI programs. (Glynn, 1986, pp. 40-42)

The answer to the second part of the question is that there are numerous organizations which have developed their own evaluation criterion for software, some of them being design, ease of use, content, motivational devices and documentation. But educators and others are questioning their validity and relevant importance. They state that

> Before educational software evaluation criteria and their associated elements can be used both efficiently and effectively for evaluating educational software, there has to be agreement between all interested parties regarding their individual relevant importance and recommended methodology for conducting educational software evaluations.
>
> In this way standardized results and ratings could be compiled on a national basis for every educational software program evaluated by schools or other organizations in support of or under contract with public schools to perform this type of service. (Glynn, 1986, pp. 43-45)

What does the future hold for CAI? One possibility is the laser-tracked video disk, a medium which would allow the computer to control video sequences in order to illustrate various concepts and then, to respond in a typical CAI fashion (Atkinson, 1984, p. 96). As far back as 1977, the education industry was looking at the video disk, hoping it would "furnish a type of CAI that was envisioned by its early pioneers, but never realized." (Hirschbuhl, 1977, p. 28) By the late 1970s, companies like Phillips-MCA made the disc available for production. Its supporters were very enthusiastic about its capabilities. L.L. Leveridge wrote in the 1979-1980 "Journal of Educational Psychology",

> The videodisk represents the most significant innovation in educational technology since the invention of the movable type by Gutenburg some 500 years ago. (Atkinson, 1984, p. 97)

R.R. Kadesch believed that the

> ...IVD [interactive videodisc] would greatly improve a system's capacity to present pictorial information and rapidly access instructional video segments...that these stand-alone systems employing interactive video and computer graphics will eventually emerge as the system of choice, especially for the nontraditional student. (Atkinson, 1984, p. 97)

In 1982, another enthusiast, A.R. Molnar saw

> ...the need for educational technology to meet the challenge of the currently expanding information boom if we are to avoid a massive "ignorance explosion." (Atkinson, 1984, p. 97)

He felt the way to solve this was through IVD.

By 1983, the software capabilities of the laser-tracked video disk were enormous. Software packages were being marketed. Ten years of high school and college training in the French language could be stored on one disk. It was felt that the micro-CAI connection would be made obsolete by the video disk. "Its interactive powers are awesome, and the learning capabilities are immersed with the visual." (Harrod and Ruggles, 1983, p. 8)

Two more possibilities include the additions of compact disc read-only memories (CD ROM) and voice synthesizers. The latter could be used in teaching a foreign language by correctly pronouncing the words at the student's request.

Today, there are some developers who feel that the market should "go slow", for some teachers are finding difficulty with the computers they are currently using. Other developers, such as Thomas Anderson, executive vice-president of Commonwealth Strategies Consulting (Boston) and director of two multimedia projects in cooperation with WNET, New York's public TV station, said "We need an integrated technology for education." He envisioned that by 1989, "a digital television set with an optional internal

32-bit microcomputer and ports for CD ROM and other peripherals" would be available for $2,500.00. (Ploch, 1986, pp. 45-46)

It is felt that artificial intelligence (AI) will soon play a role in education, by taking the student's responses, analyzing them and leading them to be able to discover their errors and correct them. AI could "allow educators to create software that helps students to learn as if they were apprentices to a master." (Ploch, 1986, p. 46)

In March 1986, Philips Corporation and Sony jointly announced their work in Compact Disc Interactive (CD-I), which will

> ...offer strong capabilities in the all-important application areas of education, 'edutainment' and entertainment. (Geest, NMS Today, 1987, p. 2)

It is felt that CD-I will give teachers more time to be able to interact with students on a one-to-one basis. One of the strengths of CD-I in education is its

> ...capacity to allow children to ask empowering conditional questions, where they could explore conditional realities and set their own rules. (Gibbon and Ruopp, 1987, p. 4)

To be able to predict what the future will be for CAI and technology is not possible, but in order to plan for the future of computers and their use in the schools, educators and administrators must become responsible for their knowledge and support of this rapidly changing technology, otherwise known as progress.

B.F. Skinner said the following about the future of the "teaching machine":

> With the help of teaching machines and instructional programs, schools can be designed so that students will profit from an immediate evaluation of what they have done and will move forward as soon as they are ready. Those who move quickly will cover many more fields, some of them possibly beyond the range of available teachers. Those who move slowly will survive as successful students. Teachers will have more time to talk with their students, and students will learn to express themselves more effectively. (Students will have a great deal more to express, as well.) Teachers will have more time to get to know students and to serve as counselors. They will have more to show for their work, and teaching will become an honored and generously rewarded profession. Because

> education will be much more efficient, it will probably cost less than it does now. This in not a utopian dream. It is well within range of an existing technology of teaching. (Skinner, B.F., 1986, p. 110)

There are some "hurdles" which must be "jumped over" in order to ensure this continues. Users must be trained to use CAI effectively, whether the user be the student or the instructor. User acceptance of CAI is also crucial. Administrators and other personnel must also be trained in its use and applications. The manufacturers of the computers used with CAI programs are making great strides towards solving these problems. They realize that fears and doubts exist in people who know little about the use of computers. The machines being manufactured today have become relatively easy to learn and use. This computer anxiety/ignorance is being reduced by the books and manuals printed on computers and their use, adult education courses and increased media attention. These items, as well as an increase in the numbers of home computers purchased, telecommunications and government and private support "are likely to lower total CAI costs, increase the CAI user base, and create an infrastructure that fosters CAI development." (Pressman and Rosenbloom, 1984, pp. 94-98)

VII. THE USE OF COMPUTERS IN NAVY TRAINING

A. HISTORIC BACKGROUND

Having established the status of computers for educational use in the public sector, it is appropriate to do the same with regard to the United States Navy. The purpose for separating the Navy's use from that of the public sector is not that the two are so dissimilar, but rather to provide for ease of comparison between the two and to set the stage for a possible follow on study by describing certain issues.

Just as in the public sector, the Navy's use of computers for training purposes is an outgrowth of B.F. Skinner's teaching machine and the programmed instruction movement of the late 1950s and early 1960s. The Navy's use of computers for instructional purposes began as a programmed instruction research and development (R&D) effort in the 1950s which was sponsored by the Office of Naval Research (ONR) and the Naval Training Research Laboratory (NTRL). This was followed by other studies sponsored directly or indirectly by ONR, or simply monitored by them, that dealt with the use of computers as an instructional device. Sources of input included the drill and practice studies of Patrick Suppes of Stanford University, the University of Pittsburg's research regarding the integration of CMI within a public school setting and Florida State University's studies regarding various aspects of CAI and CMI. The Navy's purpose with respect to these studies was to gather sufficient information regarding the cost-effectiveness of computer-based training systems. (Hansen and others, 1975 pp. 7-8) (Van Matre, 1980, p. 1).

The Navy was interested in continuing to provide student-paced instruction, because it was known that

dramatic reductions in training time could be achieved with no loss in student proficiency. The management of large-scale systems of this type however, placed heavy burdens on both the classroom instructor and higher levels of management. The use of computers to reduce some of these burdens was worthy of evaluation. (Carson and others, 1975, p. vii)

In 1966, the Assistant Secretary of Defense for Manpower and Reserve allocated $70,000 to initiate a CMI project, the focus of which was individualization of instruction, with funds provided for both CMI implementation as well as CAI explorations (Hansen and others, 1975, p. 9). The main purpose of this project

> ...was to develop and evaluate a CMI system that would be less expensive than CAI, would provide a frequency of interaction that falls somewhere between that provided by CAI and that normally provided by CMI, and would handle some of the clerical and administrative burdens that are normally imposed by student-paced instruction. (Carson and others, 1975, p. vii)

It was also during 1966 that the Office of Naval Research, in conjunction with General Learning Corporation, began the introduction of CAI into the Naval Academy. This particular case was described in Chapter IV.

The CMI project was begun in the summer of 1967 at the Naval Air Station, Millington, Tennessee, as a joint undertaking by the Chief of Naval Air Technical Training (CNATECHTRA) and the NTRL Branch Office, Memphis. The project was initiated in the Aviation Mechanical Fundamentals School, which provided instruction to Navy and Marine personnel regarding general topics related to aircraft, aircraft handling and aircraft carriers. By 1969, it had been extended to the Aviation Familiarization School, which was an orientation to naval aviation required of all trainees ordered to the Naval Air Technical Training Center, Memphis, from the Recruit Training Commands.

As was common to research in the area of training, a joint institutional development track was taken. This

involved the Navy and several outside sources.

> ...IBM prepared the first concept paper that lead to a contract with State Technical Institute of Memphis. The Memphis State University Computing Center developed the computer software that supports the CMI system. ...they used an IBM 360 Model 40 computer.
>
> Under separate contract, the Bureau of Educational Research and Services at Memphis State University supported the project with research pertaining to media selection and with assistance in preparing and coding instructional CMI materials.
>
> The University of Tennessee Biometric Computer Center adapted a relatively new CAI language, called Coursewriter III, to the CAI requirements of the project before the language was released for general use. In addition, during the initial contract with the University of Tennessee, several hours of tutorial CAI instructional material pertaining to the Navy 3-M system were developed and tested. This work involved an IBM 360 Model 40 computer with a terminal.... This terminal consists of a teletypewriter and has a random access slide and audio tape capability. The findings from this research indicated that CAI should be delayed for implementation within CMI. (Hansen and others, 1975, pp. 10-11)

Of course, a project of this size required more than the $70,000 allocated to it in 1967. Funding in subsequent years came from three other sources: the Navy's Advanced Development Objective 43-03X (Education and Training) provided $866,000, the Chief of Naval Technical Training provided $210,000 and Naval Air Systems Command provided $130,000 (Carson and others, 1975, p. 27).

In late 1970, CNATECHTRA submitted an interim report requesting approval of the CMI system as a part of Navy training. Favorable endorsements were obtained from the Chief of Naval Air Training as well as the Chief of Naval Education and Training (CNET). Finally, in early 1971, the Chief of Naval Operations (CNO) approved the request to make the CMI system operational.

One factor which contributed to the approval of CMI as an element of Navy training was that of cost saving. The goals which had been specified for the Navy's CMI system were (Hansen and others, 1975, pp. 4-5, 28, 95, 115-116):

1. An average reduction in course length of 30 percent.
2. An average reduction in instructional/support staff of 20 percent.
3. An enhancement of end of course performance levels....
4. A reduction in course attrition (rates of failure).

When the CMI proposal was initially presented to the CNO, an estimated net annual savings of $2,000,000 was reflected. This was based on the following (Hansen and others, 1975, p. 13):

1. Reduction of the Aviation Fundamentals Course from six to two weeks for an annual savings of 500 man-years.
2. Reduction of the Mechanical Fundamentals Course from three to two weeks for an annual savings of 175 man-years.
3. Reducing the number of required military instructors by 32.
4. Converting to dollars and summing the student and instructor savings resulted in a total gross savings of $2,614,720 per year.
5. CMI hardware costs were determined to be $336,000 per year if leased.
6. Computer operating and personnel costs would approximate $130,500 per year.
7. Supplies and miscellaneous expenses would be $12,000 per year.
8. Summing the various costs results in an estimated total cost of $478,500 per year.
9. Subtracting cost from gross savings results in an estimated net annual savings of over $2,000,000.

It would be possible to argue against the merits of this method of comparing costs and benefits. Considering the fact that military personnel are paid the same paygrade-based salary for being in school as they are for being on the job, no actual dollar savings with respect to student salaries is achieved through reductions in course length. The same can be said with regard to calculating the savings achieved by reducing the number of military instructors. The point here, is that reductions in course length and instructor requirements do not necessarily equate to savings, but it is not unusual to find cost/benefit studies in which this procedure is used.

In addition to justifying the cost savings of CMI, the Chief of Naval Education and Training had to justify the need to obtain additional computer resources. The reason for this was that during the evaluation phase of the CMI project, the Navy had contracted with Memphis State University to provide the necessary computer and peripheral services. Since the evaluation had shown the benefits of using CMI, CNET wanted to shift the hardware portion of the

CMI program entirely into Navy hands. This necessitated the purchase of computers, optical scanners, communication devices, teletypewriter terminals and other peripheral equipment. However, there were misconceptions at the Chief of Naval Operations and Office of the Secretary of Defense levels regarding the application of computers to training. These were overcome by CNET through

> ...the position that the management of high student density individualized instruction created such large requirements for information and data processing that the only way such individualization was possible was through the application of modern ADP techniques. Couched in these terms, the requirement for ADP support could be defended in the same context as other ADP requirements, rather than in the context of an instructional mediating device. The resources were approved with no further delays, and the long process of ADP equipment acquisition was able to commence. (Hansen and others, 1975, p. 14)

This indirect approach to obtaining the required hardware for computer-based instruction was not uncommon. In the public sector, some schools were able to implement computer-based programs only after they had convinced school officials that the computer could also help alleviate routine administrative burdens in the school's offices.

The CMI program was expanded during the 1972 to 1974 timeframe to include the Basic Electricity and Electronics course and the Aviation Mechanics Jet course. During this period, the Aviation Mechanical Fundamentals course was combined with the Aviation Familiarization course to become the Aviation Fundamentals course. The result of using CMI with these three courses was (Hansen and others, 1975, pp. 28, 90-96):

1. A reduction in course instructional length from 24 to 80 percent, with an average reduction of 46.8 percent.
2. A 23 percent reduction in instructor/support personnel.
3. A five percent increase in end of course performance levels and more positive student attitudes.
4. Lower attrition rates by 4.5 to 11.1 percent in magnitude.
5. Projected cost savings in fiscal year 1975 in excess of $10.2 million, based on savings with respect to student and instructor salaries.

These results were consistent with the Navy's objectives for CMI.

By 1975, the Navy's CMI system was supporting over 3000 students at multiple sites. This system represented

> ...an outstanding example of how an R&D activity culminated in fruition of an actual training operation. The research climate, shared civilian and uniformed personnel, a commitment to sound training design and an adaptive approach to CMI systems goals undoubtedly allowed it to move from the R&D phase to fully operational status in less than a decade. Compared to the University of Illinois PLATO system...Navy CMI is the largest and seems the natural candidate for both expansion and further elaboration in the future. (Hansen and others, 1975, p. ii)

By 1980, the Navy CMI system had grown to be one of the largest computer-based instruction systems in existence. At that time, the system managed the daily instruction progress of about 9000 students in ten technical training schools at five locations with a central computer located at the Management Information and Instructional Systems Activity (MIISA), Millington, Tennessee. The system will eventually expand to a projected capacity of about 15,000 students in 25 schools in six locations. When fully operational, the system will be responsible for managing the instruction of nearly 30 percent of all the students in Navy technical training. (Van Matre, 1980, p. 1)

B. POTENTIAL OPERATIONAL BENEFITS OF CMI

One group of authors has made the conjecture that a potential benefit of CMI may be that of reducing manning levels in the operational Navy. They base this on several factors, such as:

1. Reducing course completion time places a sailor in the fleet sooner and this additional time provides additional experiences leading to a more knowledgeable, competant individual.
2. The increased competancy due to arriving in the fleet sooner yields a performer who contributes more to shipboard readiness.
3. Such readiness permits a reduction in the manning levels for the operational Navy. (Hansen and others, 1975, pp. 95-96)

While there are obvious benefits to be gained by placing sailors in operational billets sooner, it remains to be proven that this can lead to a reduction in operational manning levels.

C. DEVELOPING INSTRUCTIONAL SYSTEMS

One item that was critical to the CMI project was the conversion of conventional course material into a computer-based individualized mode. This task required personnel who were familiar with how to develop such material as well as being able to code and debug it. The Navy's term for this process is known as Instructional Systems Development (ISD) and is defined as follows (Chief of Naval Education and Training Instruction 1500.12, 1976, p. 22):

> ...an orderly process for planning, developing, implementing and evaluating instructional programs which ensures that personnel are taught the knowledge, skills and attitudes essential for successful job performance.

ISD evolved from the systems analysis approach to the design, production and evaluation of various systems. During the 1960s there was a shift away from systems analysis, which relied upon teams of experts, towards development of formal procedures, models and design aids which allowed relatively inexperienced personnel to design instruction. These procedures were merely elaborate versions of systems analysis models and checklists. This methodology appealed to the military because of the scarcity of experts and the fact that job rotation of military personnel restricted the buildup of expertise. (Montague and Wulfeck, 1982, pp. 2-3)

Taking the ISD approach one step farther in order to accommodate for the individualized nature required of the instruction, the Navy's definition of individualized instruction must be provided (Chief of Naval Education and Training Instruction 1500.12, 1976, p. 20):

> ...instruction that attends to the individual needs of and differences among students. In the NAVEDTRACOM, properly developed individualized instruction is characterized by the following six attributes:
>
> 1. Attending to individual students' training objectives.
> 2. Allowing for individual start times.
> 3. Adjusting for individual entry skill levels.
> 4. Releasing of time constraints.
> 5. Offering of a choice of learning media.
> 6. Use of criterion referenced measures of mastery.

In keeping with the CMI project's purpose of developing an instructional system similar to that of CAI, but of a less expensive nature and with the capability of handling the clerical and administrative functions of individualized instruction, the following resulted:

> ...an instructional system was designed in which most of the instructional materials would take the form of off-line, self-admininstered packages or modules, and most of the testing would be done off-line, with answers recorded on machine-readable answer sheets. The computer would be used for such things as test scoring, diagnosis of student deficiencies, assignment of tests, assignment of new and remedial instructional materials, tracking of students through the materials and preparation of various reports required for student management. (Carson and others, 1975, p. 3)

While personnel at Memphis State University were researching such items as media selection and developing software systems to support CMI, most of the instructional materials were developed by Navy enlisted men who had attended a 13-day instructional programmers course taught at the Naval Air Technical Training Center, Memphis. They worked under the direct supervision of a civilian training specialist and received assistance from Memphis State's Bureau of Educational Research and Services. (Carson and others, 1975, p. 6) (Hansen and others, 1975, p. 10)

Contrasted with early developmental efforts in the public sector, the organized approach of the Navy CMI project was more efficient than multiple, independent procedures. The ISD approach has not been without fault however. It has been criticized for providing "what to do" information rather than "how to do it" information (Montague and Wulfeck, 1982, p. vii). Another criticism was the variable quality of personnel developing the course material and the need for a computer-based authoring system to aid and facilitate the ISD process. (Hansen and others, 1975, pp. 127, 130-131) (Montague, 1984, pp. vii, 7)

D. SOFTWARE LIBRARIES

Like that in the public sector, the transfer of CBI software is also a problem, mainly due to incompatable types of computers existing at naval activities. While there exists methods in the public sector to catalog, annotate and distribute programs, there are none in the military. One approach that has been taken is a Department of Defense program to develop a library called TRIADS to synthesize efforts in all the services related to CBI technology. Initial programs placed in the library are those which have proven themselves within the service which developed them. Future accessions will include only those programs which have successfully passed analysis to determine their usefulness and interface with either existing authoring and management support aids or establish new ones. The obvious purpose of TRIADS is to develop software and instructional quality standards, to enable adapting and enhancing of existing library programs, to provide for program demonstration and to develop user training. (Montague, 1984, p. 8)

Efforts such as TRIADS represent positive steps to establish continuity of design and more widespread use of established programs. The library program however, has been limited in its development due to funding shortfalls.

E. CONTRASTING NAVY CBI WITH THAT IN THE PUBLIC SECTOR

As in the public sector, Navy CBI evolved from the programmed instruction movement of the 1950s. However, unlike the majority of public sector approaches to computer-based education, the Navy's CBI programs have had adequate funding and have utilized an organized approach in their development. This methodology has led to a greater level of success than has been seen with most attempts in the public sector.

Just as can be seen in the public sector, several types of computers can be found at naval activities. However, the Navy's CAI and CMI systems have each been established with a common foundation, much like that seen in the University of Illinois PLATO system.

VIII. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

The purpose of this thesis was to conduct a search of available literature in order to determine the changes that have occurred in CAI over the past 20 years. The results of the search proved beneficial in that trends could be determined and a framework established for further research.

B. CONCLUSIONS

In the late 1950s, teaching machines introduced the concept of programmed instruction. One of the designers of these teaching machines was B.F. Skinner. Within the next ten years, Computer-Based Instruction (CBI) was developed by IBM who later renamed it Computer Assisted Instruction (CAI). During the 1960s, languages such as Coursewriter I were developed for use with CAI. These languages served as a shell, and as such, facilitated the writing of CAI materials. Also, since the introduction of the microcomputer in the latter part of the 1970s, computers have been used more and more within schools, homes and businesses.

Many research studies regarding the use of computers in education have been conducted. As early as 1963, Patrick Suppes and others at Stanford University began research to determine if CAI was a beneficial education medium and if it was, how should it be used. One question to be answered centered on whether it should be used in conjunction with the teacher or as a stand alone system. Since then, numerous other studies have been conducted throughout the world on the benefits and drawbacks of CAI.

CAI has been defined in numerous ways, but can be simply defined as "instruction that is assisted or aided through use of the computer" (Harrod and Ruggles, 1983, p. 3).

There have been many look alikes developed since CAI began, some of them being Computer Managed Instruction (CMI), Computer-Based Education (CBE) and Computer Assisted Learning (CAL). Within each of these, specific systems were developed in order to enhance their success.

There are different categories or methodologies of instruction which have been developed and still being used today. These include drill and practice, tutorial, simulation, instructional games, computer-based tests, problem solving demonstrations and mini-programming for CAI.

Advantages and disadvantages of CAI have been cited since its inception. Numerous civilian and military studies have pointed out specific advantages such as savings in instructional time and increased quality of training. There are basically two types of disadvantages with CAI. These are categorized as either being state of the art disadvantages, which include software and personnel, or inherent disadvantages, which include cost and time.

Educators must first develop an understanding of just what CAI is. After that, they then need to develop an awareness of these advantages and disadvantages so that they can be weighed with other factors present on the job, in order to determine if CAI would prove beneficial in their case.

When CAI was first introduced, the constraining factor was the cost of hardware, for, at that time, there only existed what are now known as mainframes and minicomputers. Over time, the cost of hardware has fallen as the result of improvements in technology and the manufacturing process. The opposite has occurred with regard to software. In the beginning stages of CAI, the software did not exist. What was done was to adapt Programmed Instruction (PI) textbooks to the computer. These types of conversions did not cost very much, but for the most part only resulted in using the computer as an expensive page turner. Also, over time, it

was recognized that better software was required. Developing better software required the interaction of several types of individuals. Among them, were educators, programmers, graphics artists and others. These actions, in turn, resulted in increased development costs and thereby raised the price of software.

During the late 1960s, the introduction of four CAI courses at the Naval Academy required an enormous investment in development time. Times ranged from 85 to 905 hours per instructional hour. Today's software houses estimate that $500,000 to $1,500,000 is required to develop quality software.

Instructional systems also evolved during the 1960s. These systems combined hardware and educational software into one package. An example of such a system is PLATO, which has now grown to a system of 19 computers and 8000 terminals scattered throughout the world. In 1979, the yearly cost for a school to utilize this system ranged from $44,000 to $95,000, depending on the method of calculation chosen. This represented a considerable savings over the CAI costs of the 1960s when just the hardware cost alone would comprise six to seven figures. Today's microcomputer has slashed the hardware cost even further. Extremely capable microcomputers can now be purchased for under $1000.

In the early stages of CAI, due to the inadequacy of existing programs, some teachers began programming their own CAI material. While they were doing that, programmers continued to develop their version of CAI software. The resulting product often reflected poor programming skill on the part of the teacher and a lack of understanding the educational process on the part of the programmers.

Many studies conducted by government appointed groups, congressional committees and others reached the basic conclusion that the amount of hardware continues to grow, but the quality of software was not improving as rapidly.

Areas recommended for improvement by these groups included more teacher education and the establishment of development groups by the software manufacturers. The recommendation concerning the development groups was made as early as the late 1960s and as recently as the mid 1980s.

Several factors caused the software manufacturers to be less than enthusiastic about investing large sums of money into the development of quality software. Some of these included the lack of a sufficient hardware base during the early years of CAI; the limited memory of a majority of the school's computers precluded the development of sophisticated programs, and the combined effect of inequitable hardware distribution among schools, an inadequate school computer purchase plan, a lack of teacher training and apprehension among some teachers with regard to computers which has not been conducive to fostering positive attitudes about CAI. Some of these problems have been somewhat alleviated due to school training programs and the growing base of microcomputers.

Over time however, a growing volume of software, some of which was known to be virtually worthless, created selection problems for teachers. As a result, software evaluation organizations were created. These groups act independently to examine software and promulgate critical evaluation reports to educators. Some of these groups are able to match CAI software with specific courses.

One area that continues to be mentioned as requiring more research, is that of learning theory. By conducting such research, a better understanding of the computer-based learning process can be obtained and this could, it is believed, lead to better software.

It is hard to predict what the future will bring to the use of computers in education. It is known that within a four year period from 1983 to 1986, the number of computers that were sold increased by a factor of five, rising from

two to ten million units. Children are not only able to utilize the computer more in the classroom, but many are also able to utilize the computer once they go home. This increases their computer literacy.

Many predictions have been made as to what will occur in the future for CAI. One specific prediction is that the number of computers in schools will continue to increase. There are however, some items that must be taken into account in order to accommodate the continuous rise in CAI that is occurring. Large corporations are getting involved in developing quality CAI software and courseware, and this is increasing the receptivity for CAI in more schools and school districts; criterion are being developed in order to evaluate software with regard to its quality and capability, and the demand for good educational software is continually rising. Some of the possibilities for CAI in the future include the use of laser tracked video disks, CD ROM, voice synthesizers and artificial intelligence.

There are some who think that the market should slow its pace and allow teachers who have neglected CAI to catch up to their contemporaries. Others feel just the opposite, and favor a continually advancing market.

Certain hurdles must be overcome in order to ensure the success of CAI. These include effective user training, including that for administrators as well as teachers; achievement of a greater level of CAI acceptance; overcoming the fear of computers; reducing costs, and more government support.

The use of computers in Navy training has grown from the same programmed instruction base that the public sector has. The major difference between the two is that the funding and organized development approach used by the Navy has resulted in a more well-founded instructional system than that found in most public schools. The exception to this is the University of Illinois PLATO system, which competes with the

Navy's CMI system in being one of the largest instructional systems in the world.

C. RECOMMENDATIONS

This thesis can serve as a background or introductory study for future students to conduct similar research with regard to CAI in the U.S. Navy. There are certain issues which need to be addressed. It has been recognized that the plan for a 600-ship Navy will require a greater number of support personnel. It will also place increased tasking on the Navy's training activities. One possible solution to this problem is for Naval Training Commands to expand the use of CAI. In order to determine if this is feasible, there are certain items that need to be researched. These include:

1. The ashore training requirements for a 600-ship Navy.
2. The number of qualified instructor personnel that will be required to fill instructor billets at training commands.
3. Projection of these requirements into the future in order to determine if training requirements can be met using existing facilities and systems.

There are also other issues that are suitable for inclusion in a follow-on work. These issues are:

1. A historical review of the use of CAI in the Navy with regard to current and proposed areas of research for improving existing systems.
2. Determining why CAI is being used in specific training courses and not in others. Sources of information for this topic include the Chief of Naval Education and Training, Chief of Naval Air Training, Chief of Naval Technical Training, Naval Training Centers and Naval Technical Training Centers.
3. Understanding Navy goals for the use of CAI.

4. Determining whether or not the Navy courses utilizing CAI are meeting the objectives of the Navy with regard to CAI.
5. Determining what the Navy sees as its use of CAI in the future.
6. Determining the effect, if any, that increased or expanded use of CAI in the Navy would have on enhancing the manning of the 600-ship Navy.
7. The possible impact on naval training programs of changing demographics with regard to draft-eligible males and the manning requirements for 600 ships.

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